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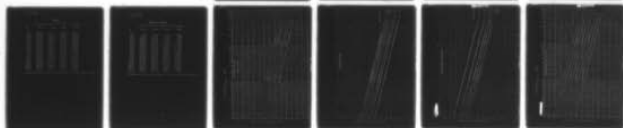
NAVAL UNDERSEA WARFARE CENTER SAN DIEGO CALIF
VALUES OF EMPIRICAL EXPRESSIONS FOR AMBIENT SEA AND SHIP NOISE.(U)
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(11) FEBRUARY 1968

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(6)

VALUES OF EMPIRICAL EXPRESSIONS
FOR AMBIENT SEA AND SHIP NOISE-(U)

(10) H. R. Hall

San Diego, California

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This technical note describes a portion of a prediction model presently in use at the Naval Undersea Warfare Center, San Diego Division. This note is not to be considered as an official NUWC report. Its purpose is to document the existing model to the extent required by Navy project offices for whom predictions have been made.

The work described in this technical note has been supported under NAVSHIPS Exploratory Development subproject SF 101 03 21, Task 8704, and by Independent Research funds under NAVSHIPS subproject ZR 011 01 01.

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↓ The sonar-system prediction models currently used by NUWC, San Diego, Code D556, contain empirical expressions for ambient sea noise and for ship noise. The purpose of this technical note is to provide interested persons at NUWC with these empirical noise expressions, as well as graphs and tabulated values of the expressions at selected values of their independent variables (i.e., frequency, wave-height, and ship speed). ↑

The following expressions are currently in use:

a. Ambient sea noise

$$NSEA = -42 -16.67 \text{ LOG}(f) + 10.35 \text{ LOG}(L) \text{ dB re } 1\mu\text{B} \quad (1)$$

b. Sea component of ship noise

$$NSS = -42.94 -16.67 \text{ LOG}(f) + 2L \text{ dB re } 1\mu\text{B} \quad (2)$$

c. Speed component of ship noise

$$NSV = -44 -16.67 \text{ LOG}(f) + 1.15V \text{ dB re } 1\mu\text{B} \quad (3)$$

where

f = frequency in KHZ,

L = wave-height in ft,

and

V = ship speed in kts.

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Equation (1) is an attempt to predict the Knudsen curves,¹ which are shown in figure 1. Since wave-height and frequency are the only independent variables in this equation, it cannot possibly correlate exactly with the Knudsen curves, which use sea-state (a combination of environmental factors) and frequency as independent variables. Table 1 gives a rough correspondence of wave-height and sea-state for use in equation 1. (No physical significance should be given to the lower values of wave-height in table 1.)

Equations (2) and (3) represent an empirical fit to the ship-noise measurements reported by CDR Fridge.^{2,3}

Values obtained for *NSEA*, *NSS*, and *NSV* for selected values of frequency, wave-height, and ship speed appear in tables 2, 3, and 4, and figures 2, 3, and 4, respectively.

In addition to the above expressions, the sonar-system programs provide two other noise options:

- a. Noise can be eliminated entirely as a factor in performance evaluation.
- b. Total ship noise can be put into the program as an interpolated function of ship speed, in which case equations (2) and (3) are not used.

The possibility of modifying these expressions, using some of the results⁴ in the article by Wenz, is currently being investigated.

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REFERENCES:

1. National Defense Research Committee. Division 6 Report 6.1-NDRC-1848, *Survey of Underwater Sound: Report No. 3; Ambient Noise*, by V. Knudsen and R. C. Alford, 26 September 1944
2. Underwater Sound Laboratory Report 548, *A Sonar Proposal for the 1965 ASW Destroyer*, by H. E. Fridge, CONFIDENTIAL, 15 June 1962
3. Underwater Sound Laboratory Technical Memorandum 930-0190-61, *Proposed Sonar Self-Noise Standards for Surface Ships*, by H. E. Fridge, CONFIDENTIAL, 15 September 1961
4. Wenz, G. M., "Acoustic Ambient Noise in the Ocean: Spectra and Sources," *JASA*, v 34, p 1936-1956, December 1962

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TABLE 1

<u>SEA STATE</u>	<u>WAVE-HEIGHT (ft)</u>
0	.045
1/2	.21
1	.50
2	2
3	4.1
4	6.3
5	9.8
6	15.3

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TABLE 2

AMBIENT SEA NOISE IN DB RE 1μB

L=	0.04	0.21	0.50	1.00	1.50	2.00
F						
0.10	-39.27	-32.34	-28.44	-25.33	-23.50	-22.21
0.15	-42.67	-35.74	-31.84	-28.73	-26.91	-25.61
0.25	-45.90	-38.93	-35.03	-31.96	-30.14	-28.84
0.35	-48.34	-41.41	-37.51	-34.40	-32.57	-31.28
0.63	-52.59	-45.67	-41.77	-38.65	-36.83	-35.54
1.00	-55.94	-49.01	-45.11	-42.00	-40.17	-38.88
1.25	-57.55	-50.63	-46.73	-43.61	-41.79	-40.50
1.60	-59.34	-52.41	-48.52	-45.40	-43.58	-42.28
2.00	-60.95	-54.03	-50.13	-47.02	-45.19	-43.90
2.50	-62.57	-55.65	-51.75	-48.63	-46.81	-45.51
3.00	-63.89	-56.97	-53.07	-49.95	-48.13	-46.83
3.50	-65.01	-58.03	-54.18	-51.07	-49.24	-47.95
4.00	-65.97	-59.05	-55.15	-52.03	-50.21	-48.92
5.00	-67.59	-60.66	-56.76	-53.65	-51.83	-50.53
6.30	-69.26	-62.34	-58.44	-55.32	-53.50	-52.21
8.00	-70.99	-64.07	-60.17	-57.05	-55.23	-53.94
10.00	-72.61	-65.68	-61.78	-58.67	-56.84	-55.55
15.00	-76.01	-69.09	-65.19	-62.07	-60.25	-58.95
25.00	-79.24	-72.32	-68.42	-65.30	-63.48	-62.18
35.00	-81.68	-74.75	-70.85	-67.74	-65.92	-64.62
63.00	-85.93	-79.01	-75.11	-71.99	-70.17	-68.88

F=FREQUENCY IN KHZ, L=WAVE HEIGHT IN FT, AND V=SHIP SPEED IN KTS.

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TABLE 2 (continued)
 AMBIENT SEA NOISE IN DB RE 1μB

L=	2.50	3.00	3.50	4.00	4.10	4.50
F						
0.10	-21.21	-20.39	-19.69	-19.09	-18.98	-18.57
0.15	-24.61	-23.79	-23.10	-22.50	-22.39	-21.97
0.25	-27.84	-27.02	-26.33	-25.73	-25.62	-25.20
0.35	-30.28	-29.45	-28.76	-28.16	-28.05	-27.63
0.63	-34.53	-33.71	-33.02	-32.42	-32.31	-31.89
1.00	-37.88	-37.06	-36.37	-35.77	-35.65	-35.24
1.25	-39.49	-38.67	-37.98	-37.38	-37.27	-36.85
1.60	-41.28	-40.46	-39.77	-39.17	-39.06	-38.64
2.00	-42.90	-42.08	-41.38	-40.78	-40.67	-40.25
2.50	-44.51	-43.69	-43.00	-42.40	-42.29	-41.87
3.00	-45.83	-45.01	-44.32	-43.72	-43.61	-43.19
3.50	-46.95	-46.13	-45.44	-44.84	-44.72	-44.31
4.00	-47.91	-47.10	-46.40	-45.80	-45.69	-45.27
5.00	-49.53	-48.71	-48.02	-47.42	-47.31	-46.89
6.30	-51.20	-50.38	-49.69	-49.09	-48.98	-48.56
8.00	-52.93	-52.11	-51.42	-50.82	-50.71	-50.29
10.00	-54.55	-53.73	-53.04	-52.44	-52.32	-51.91
16.00	-57.95	-57.13	-56.44	-55.84	-55.73	-55.31
25.00	-61.18	-60.36	-59.67	-59.07	-58.96	-58.54
35.00	-63.62	-62.80	-62.11	-61.51	-61.39	-60.98
63.00	-67.88	-67.06	-66.36	-65.76	-65.65	-65.23

F=FREQUENCY IN KHZ, L=WAVE HEIGHT IN FT, AND V=SHIP SPEED IN KTS.

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TABLE 2 (continued)
 AMBIENT SEA NOISE IN DB RE 1μB

L=	5.00	6.30	7.50	9.80	15.30	20.00
F						
0.10	-18.09	-17.05	-16.27	-15.07	-13.06	-11.86
0.15	-21.49	-20.46	-19.67	-18.47	-16.47	-15.26
0.25	-24.73	-23.69	-22.90	-21.70	-19.70	-18.49
0.35	-27.16	-26.12	-25.34	-24.14	-22.13	-20.93
0.63	-31.42	-30.38	-29.59	-28.39	-26.39	-25.19
1.00	-34.76	-33.72	-32.94	-31.74	-29.73	-28.53
1.25	-36.38	-35.34	-34.56	-33.35	-31.35	-30.15
1.60	-38.17	-37.13	-36.34	-35.14	-33.14	-31.93
2.00	-39.78	-38.74	-37.96	-36.76	-34.75	-33.55
2.50	-41.40	-40.36	-39.57	-38.37	-36.37	-35.16
3.00	-42.72	-41.68	-40.89	-39.69	-37.69	-36.48
3.50	-43.83	-42.79	-42.01	-40.81	-38.81	-37.60
4.00	-44.80	-43.76	-42.98	-41.77	-39.77	-38.57
5.00	-46.41	-45.38	-44.59	-43.39	-41.39	-40.18
6.30	-48.09	-47.05	-46.27	-45.06	-43.06	-41.86
8.00	-49.62	-48.78	-47.99	-46.79	-44.79	-43.59
10.00	-51.43	-50.39	-49.61	-48.41	-46.41	-45.20
16.00	-54.84	-53.80	-53.01	-51.81	-49.81	-48.60
25.00	-58.07	-57.03	-56.24	-55.04	-53.04	-51.83
35.00	-60.50	-59.46	-58.68	-57.48	-55.48	-54.27
63.00	-64.76	-63.72	-62.94	-61.73	-59.73	-58.53

F=FREQUENCY IN KHZ, L=WAVE HEIGHT IN FT, AND V=SHIP SPEED IN KTS.

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TABLE 3
SEA COMPONENT OF SHIP NOISE IN DB RE 1μB

L=	0.04	0.21	0.50	1.00	1.50	2.00
F						
0.10	-26.18	-25.85	-25.27	-24.27	-23.27	-22.27
0.16	-29.58	-29.25	-28.67	-27.67	-26.67	-25.67
0.25	-32.81	-32.43	-31.90	-30.90	-29.90	-28.90
0.35	-35.25	-34.92	-34.34	-33.34	-32.34	-31.34
0.63	-39.50	-39.17	-38.59	-37.59	-36.59	-35.59
1.00	-42.85	-42.52	-41.94	-40.94	-39.94	-38.94
1.25	-44.46	-44.13	-43.55	-42.55	-41.55	-40.55
1.60	-46.25	-45.92	-45.34	-44.34	-43.34	-42.34
2.00	-47.87	-47.54	-46.96	-45.96	-44.96	-43.96
2.50	-49.48	-49.15	-48.57	-47.57	-46.57	-45.57
3.00	-50.80	-50.47	-49.89	-48.89	-47.89	-46.89
3.50	-51.92	-51.59	-51.01	-50.01	-49.01	-48.01
4.00	-52.88	-52.55	-51.97	-50.97	-49.97	-48.97
5.00	-54.50	-54.17	-53.59	-52.59	-51.59	-50.59
6.30	-56.17	-55.84	-55.26	-54.26	-53.26	-52.26
8.00	-57.90	-57.57	-56.99	-55.99	-54.99	-53.99
10.00	-59.52	-59.19	-58.61	-57.61	-56.61	-55.61
16.00	-62.92	-62.59	-62.01	-61.01	-60.01	-59.01
25.00	-66.15	-65.82	-65.24	-64.24	-63.24	-62.24
35.00	-68.59	-68.26	-67.68	-66.68	-65.68	-64.68
63.00	-72.84	-72.51	-71.93	-70.93	-69.93	-68.93

F=FREQUENCY IN KHZ, L=WAVE HEIGHT IN FT, AND V=SHIP SPEED IN KTS.

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TABLE 3 (continued)
SEA COMPONENT OF SHIP NOISE IN DB RE 1 μ B

L=	2.50	3.00	3.50	4.00	4.10	4.50
F						
0.10	-21.27	-20.27	-19.27	-18.27	-18.07	-17.27
0.15	-24.67	-23.67	-22.67	-21.67	-21.47	-20.67
0.25	-27.90	-26.90	-25.90	-24.90	-24.70	-23.90
0.35	-30.34	-29.34	-28.34	-27.34	-27.14	-26.34
0.63	-34.59	-33.59	-32.59	-31.59	-31.39	-30.59
1.00	-37.94	-36.94	-35.94	-34.94	-34.74	-33.94
1.25	-39.55	-38.55	-37.55	-36.55	-36.35	-35.55
1.60	-41.34	-40.34	-39.34	-38.34	-38.14	-37.34
2.00	-42.96	-41.96	-40.96	-39.96	-39.76	-38.96
2.50	-44.57	-43.57	-42.57	-41.57	-41.37	-40.57
3.00	-45.89	-44.89	-43.89	-42.89	-42.69	-41.89
3.50	-47.01	-46.01	-45.01	-44.01	-43.81	-43.01
4.00	-47.97	-46.97	-45.97	-44.97	-44.77	-43.97
5.00	-49.59	-48.59	-47.59	-46.59	-46.39	-45.59
6.30	-51.26	-50.26	-49.26	-48.26	-48.06	-47.26
8.00	-52.99	-51.99	-50.99	-49.99	-49.79	-48.99
10.00	-54.61	-53.61	-52.61	-51.61	-51.41	-50.61
16.00	-58.01	-57.01	-56.01	-55.01	-54.81	-54.01
25.00	-61.24	-60.24	-59.24	-58.24	-58.04	-57.24
35.00	-63.68	-62.68	-61.68	-60.68	-60.48	-59.68
63.00	-67.93	-66.93	-65.93	-64.93	-64.73	-63.93

F=FREQUENCY IN KHZ, L=WAVE HEIGHT IN FT, AND V=SHIP SPEED IN KTS.

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TABLE 3 (continued)

SEA COMPONENT OF SHIP NOISE IN DB RE 1μB

L=	5.00	6.30	7.50	9.80	15.30	20.00
F						
0.10	-16.27	-13.67	-11.27	- 6.67	4.33	13.73
0.16	-19.67	-17.07	-14.67	-10.07	0.92	10.32
0.25	-22.90	-20.30	-17.90	-13.30	- 2.30	7.09
0.35	-25.34	-22.74	-20.34	-15.74	- 4.73	4.66
0.63	-29.59	-26.99	-24.59	-19.99	- 8.99	0.40
1.00	-32.94	-30.34	-27.94	-23.34	-12.34	- 2.94
1.25	-34.55	-31.95	-29.55	-24.95	-13.95	- 4.55
1.60	-36.34	-33.74	-31.34	-26.74	-15.74	- 6.34
2.00	-37.96	-35.36	-32.96	-28.35	-17.35	- 7.95
2.50	-39.57	-36.97	-34.57	-29.97	-18.97	- 9.57
3.00	-40.89	-38.29	-35.89	-31.29	-20.29	-10.89
3.50	-42.01	-39.41	-37.01	-32.41	-21.41	-12.01
4.00	-42.97	-40.37	-37.97	-33.37	-22.37	-12.97
5.00	-44.59	-41.99	-39.59	-34.99	-23.99	-14.59
6.30	-46.26	-43.66	-41.26	-36.66	-25.66	-16.26
8.00	-47.99	-45.39	-42.99	-38.39	-27.39	-17.99
10.00	-49.61	-47.01	-44.61	-40.01	-29.01	-19.61
16.00	-53.01	-50.41	-48.01	-43.41	-32.41	-23.01
25.00	-55.24	-53.64	-51.24	-45.64	-35.64	-26.24
35.00	-58.68	-56.08	-53.68	-49.08	-39.08	-28.68
63.00	-62.93	-60.33	-57.93	-53.33	-42.33	-32.93

F=FREQUENCY IN KHZ, L=WAVE HEIGHT IN FT, AND V=SHIP SPEED IN KTS.

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TABLE 4

SPEED COMPONENT OF SHIP NOISE IN DB RE 1μB

V=	0.00	5.00	10.00	15.00
F				
0.10	-27.33	-21.53	-15.83	-10.08
0.16	-30.73	-24.93	-19.23	-13.48
0.25	-33.96	-28.21	-22.46	-16.71
0.35	-36.40	-30.65	-24.90	-19.15
0.63	-40.65	-34.90	-29.15	-23.40
1.00	-44.00	-38.25	-32.50	-26.75
1.25	-45.61	-39.86	-34.11	-28.36
1.60	-47.40	-41.65	-35.90	-30.15
2.00	-49.02	-43.27	-37.52	-31.76
2.50	-50.63	-44.88	-39.13	-33.38
3.00	-51.95	-46.20	-40.45	-34.70
3.50	-53.07	-47.32	-41.57	-35.82
4.00	-54.03	-48.28	-42.53	-36.78
5.00	-55.65	-49.90	-44.15	-38.40
6.30	-57.32	-51.57	-45.82	-40.07
8.00	-59.05	-53.30	-47.55	-41.80
10.00	-60.67	-54.92	-49.17	-43.42
16.00	-64.07	-58.32	-52.57	-46.82
25.00	-67.30	-61.55	-55.30	-50.05
35.00	-69.74	-63.99	-58.24	-52.49
63.00	-73.99	-68.24	-62.49	-56.74

F=FREQUENCY IN KHZ, L=WAVE HEIGHT IN FT, AND V=SHIP SPEED IN KTS.

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TABLE 4 (continued)

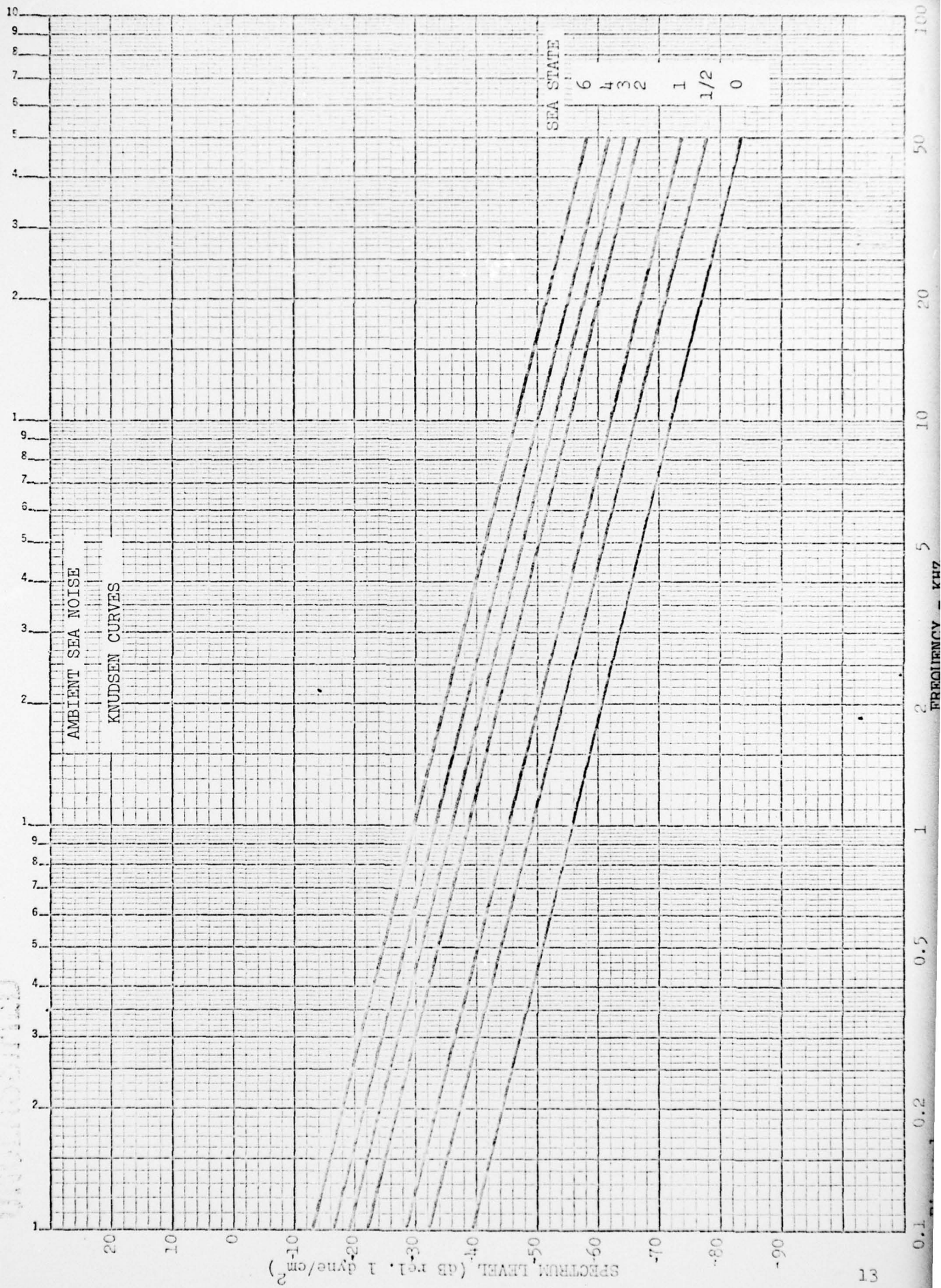
SPEED COMPONENT OF SHIP NOISE IN DB RE 1μB

V=	20.00	25.00	30.00	35.00
F				
0.10	- 4.33	1.42	7.17	12.92
0.16	- 7.73	- 1.93	3.76	9.51
0.25	-10.96	- 5.21	0.53	6.23
0.35	-13.40	- 7.64	- 1.89	3.35
0.63	-17.65	-11.90	- 6.15	- 0.40
1.00	-21.00	-15.25	- 9.50	- 3.75
1.25	-22.61	-16.86	-11.11	- 5.36
1.60	-24.40	-18.65	-12.90	- 7.15
2.00	-26.01	-20.26	-14.51	- 8.76
2.50	-27.63	-21.88	-16.13	-10.38
3.00	-28.95	-23.20	-17.45	-11.70
3.50	-30.07	-24.32	-18.57	-12.82
4.00	-31.03	-25.28	-19.53	-13.78
5.00	-32.65	-26.90	-21.15	-15.40
6.30	-34.32	-28.57	-22.82	-17.07
8.00	-36.05	-30.30	-24.55	-18.80
10.00	-37.67	-31.92	-26.17	-20.42
16.00	-41.07	-35.32	-29.57	-23.82
25.00	-44.30	-38.55	-32.80	-27.05
35.00	-46.74	-40.99	-35.24	-29.49
63.00	-50.99	-45.24	-39.49	-33.74

F=FREQUENCY IN KHZ, L=WAVE HEIGHT IN FT, AND V=SHIP SPEED IN KTS.

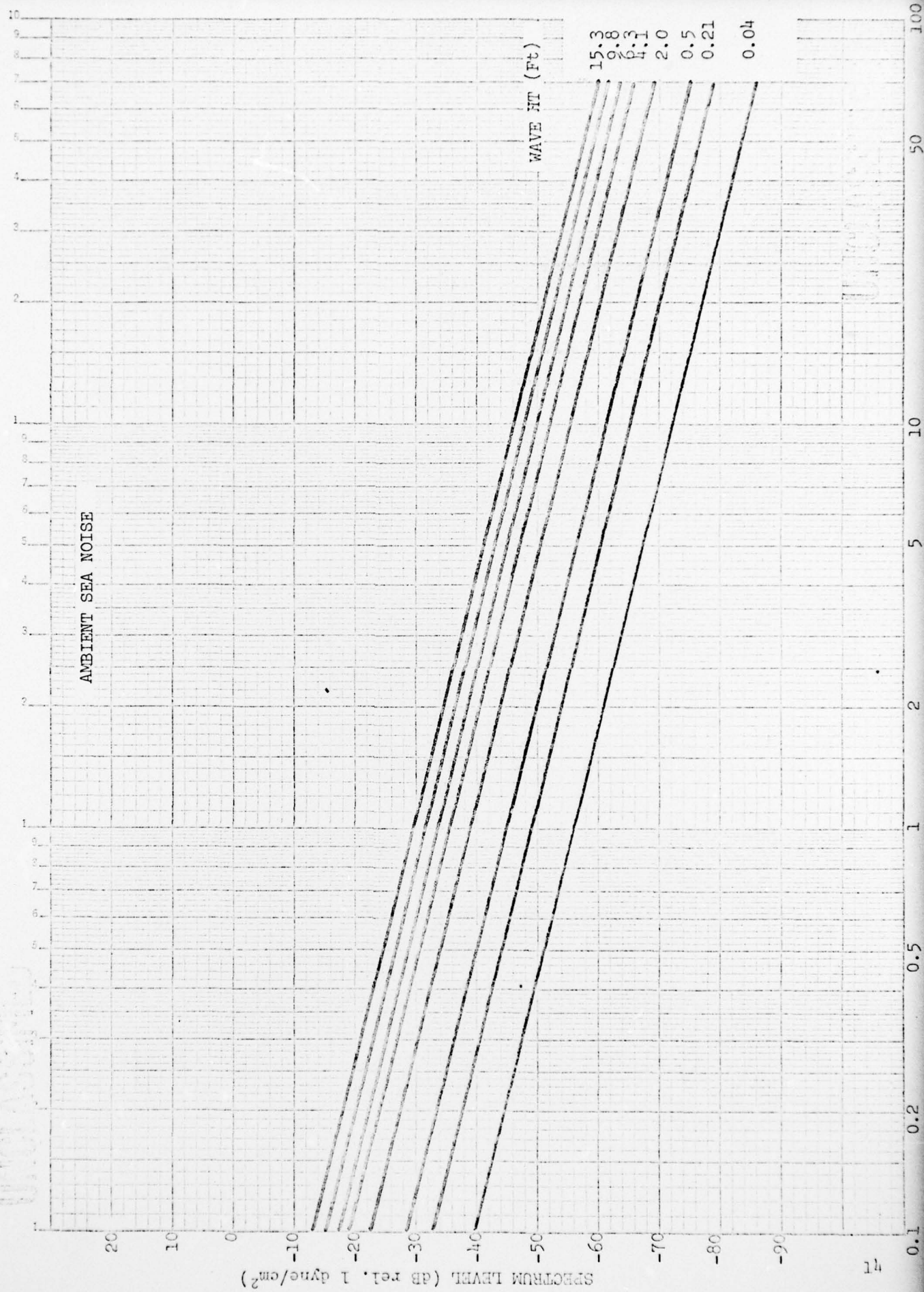
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NAVY RESEARCH & DEVELOPMENT ADMINISTRATION
RESEARCH & ENGINEERING CO.

[REDACTED]

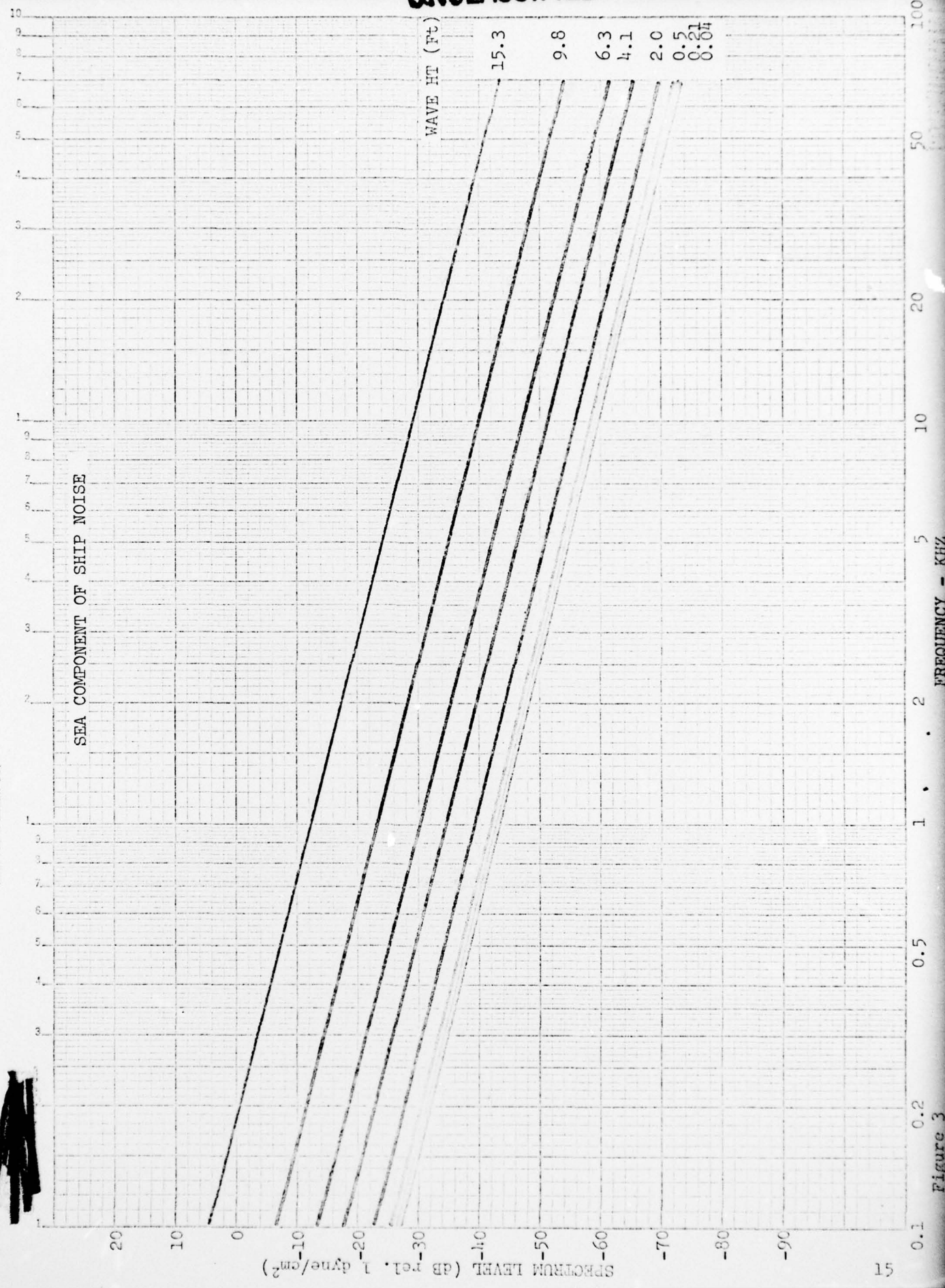


Figure 3

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3 CYCLES X 70 DIVISIONS • ALBAHENE®
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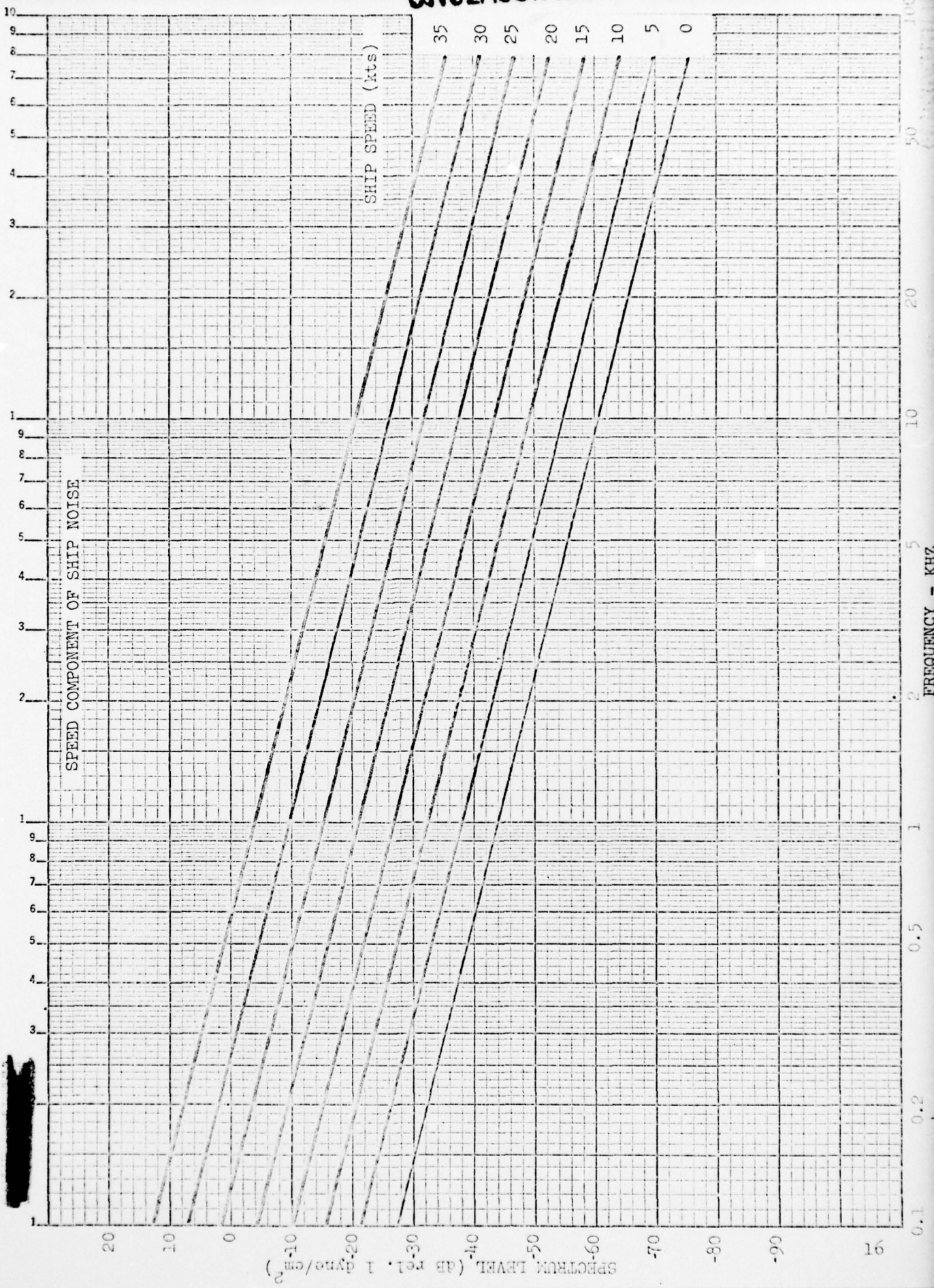


Figure 4